(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
10 October 2002 (10.10.2002)

PCT

(10) International Publication Number
WO 02/080190 A1

(51) International Patent Classification⁷: G21D 3/08, F02C 9/16, 1/05

(21) International Application Number: PCT/IB02/00979

(22) International Filing Date: 28 March 2002 (28.03.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

2001/2646	30 March 2001 (30.03.2001)	ZA
2001/2915	9 April 2001 (09.04.2001)	ZA
2001/4319	25 May 2001 (25.05.2001)	ZA
2002/1155	11 February 2002 (11.02.2002)	ZA

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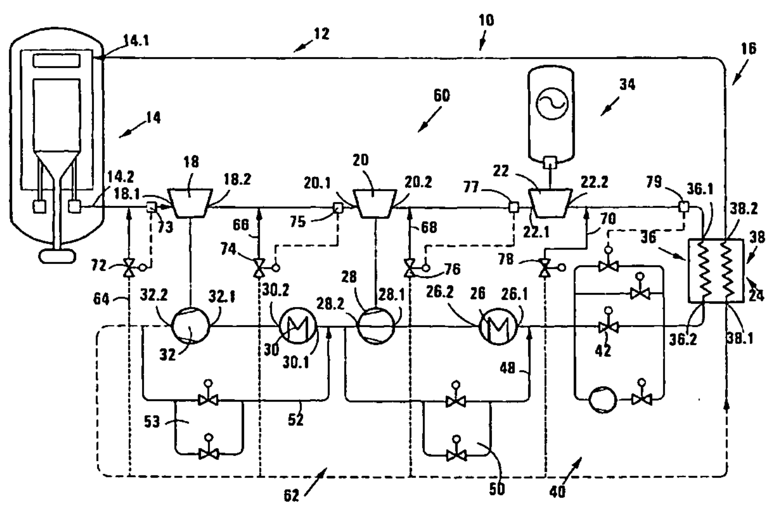
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: NUCLEAR POWER PLANT



(57) **Abstract:** A nuclear power plant makes use of a high temperature gas cooled reactor. Under certain circumstances, the possibility exists that the temperature of gas entering various components of the plant exceeds desired operating parameters. To prevent this, the temperature of the gas entering at least one of the components of the power plant is monitored and, should the temperature of the gas exceed a predetermined temperature, cooler gas is mixed with the gas whose temperature had exceeded the predetermined temperature, to reduce the temperature of the gas. Accordingly, the plant includes at least one coolant feedline leading from a source of coolant gas, typically at a point in the power generation circuit where the temperature of the gas is relatively low, to a position upstream of the component. A coolant valve is mounted in the coolant feedline to regulate the flow of coolant gas therethrough.

WO 02/080190 A1

Published:

— *with international search report*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*
— *entirely in electronic form (except for this front page) and available upon request from the International Bureau*

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NUCLEAR POWER PLANT AND METHOD OF OPERATING THE SAME

THIS INVENTION relates to a nuclear power plant. More particularly it relates to a method of operating the nuclear power plant.

According to one aspect of the invention, in a nuclear power plant which uses gas as the working fluid, there is provided a method of operating the nuclear power plant, which includes the steps of

monitoring the temperature of the gas entering at least one of the components of the power plant; and

if the temperature of the gas entering the at least one component of the power plant exceeds a predetermined maximum temperature, mixing cooler gas with the gas whose temperature has exceeded the predetermined maximum temperature, to reduce the temperature of the gas before it enters the at least one component.

When the nuclear power plant includes a high temperature gas, typically helium, cooled reactor and a power conversion unit which is connected together with the reactor in a closed loop and which includes a high pressure turbine, a low pressure turbine, a power turbine, a counterflow recuperator having a high pressure side and a low pressure side, each side having an inlet and an outlet, a low pressure compressor to which the low pressure turbine is drivingly connected, and a high

pressure compressor to which the high pressure turbine is drivingly connected, the method may include the steps of

monitoring the temperature of the gas entering at least one of the high pressure turbine, the low pressure turbine, the power turbine and the low pressure side of the recuperator; and

if the temperature of the gas entering the at least one of the high pressure turbine, low pressure turbine, power turbine, and low pressure side of the recuperator, exceeds a predetermined maximum temperature, mixing cooler gas with the gas the temperature of which has exceeded the predetermined maximum temperature, to reduce the temperature of the gas before it enters the at least one of the high pressure turbine, low pressure turbine, power turbine and low pressure side of the recuperator.

When the reactor and the power conversion unit are connected together in a closed loop power generation circuit having a high temperature section and a low temperature section, the source of the cooler gas may be the low temperature section of the power generation circuit, the method then including feeding the cooler gas from the low temperature section of the power generation circuit to a position in the high temperature section of the circuit upstream of the at least one of the high pressure turbine, low pressure turbine, power turbine and low pressure side of the recuperator.

The method may include regulating the flow of gas from the low temperature section of the circuit to the high temperature section of the circuit by means of at least one coolant valve.

According to another aspect of the invention there is provided a nuclear power plant which includes

a high temperature gas cooled reactor and a power conversion unit connected together with the reactor in a closed loop power generation circuit;

temperature sensing means for sensing the temperature of a gas entering at least one component of the power generation circuit;

at least one coolant feed line leading from a source of coolant gas to a position upstream of the at least one component; and

a coolant valve mounted in the coolant feed line and arranged to regulate the flow of coolant gas through the coolant feed line in response to signals received from the temperature sensing means thereby to permit the temperature of the gas entering the at least one component to be regulated.

The power conversion unit may include a high pressure turbine, a low pressure turbine, a power turbine, a counterflow recuperator having a high pressure and a low pressure side, each side having an inlet and an outlet, a low pressure compressor to which the low pressure turbine is drivingly connected, a high pressure compressor to which the high pressure turbine is drivingly connected, a pre-cooler positioned in series upstream of the low pressure compressor and an intercooler positioned between the low pressure compressor and the high pressure compressor, the power generation circuit having a high temperature section defined on the reactor side of the recuperator and a low temperature section defined on the other side of the recuperator, the plant including

temperature sensing means for sensing the temperature of gas entering at least one of the high pressure turbine, low pressure turbine, power turbine and low pressure side of the recuperator;

at least one coolant feedline extending from the low temperature section of the circuit to a position upstream of the at least one of the

high pressure turbine, low pressure turbine, power turbine and low pressure side of the recuperator; and

a coolant valve mounted in the coolant feedline and arranged to regulate the flow of gas through the coolant feed line from the low temperature section of the circuit to the high temperature section of the circuit in response to a signal received from the temperature sensing means.

More particularly, the reactor typically has an outlet which is connected to an inlet of the high pressure turbine, an outlet of the high pressure turbine being connected to an inlet of the low pressure turbine, an outlet of the low pressure turbine being connected to an inlet of the power turbine, an outlet of the power turbine beingconnected to an inlet of the low pressure side of the recuperator, an outlet of the low pressure side of the recuperator being connected via the pre-cooler to the inlet of the low pressure compressor, an outlet of the low pressure compressor being connected via the intercooler to an inlet of the high pressure compressor, an outlet of the high pressure compressor being connected to an inlet of the high pressure side of the recuperator and an outlet of the high pressure side of the recuperator being connected to an inlet of the reactor.

A temperature sensing means, a coolant feedline and a coolant valve may be provided in respect of each of the high pressure turbine, the low pressure turbine, the power turbine and the inlet on the low pressure side of the recuperator to regulate the temperature of gas being fed thereto.

The coolant feedlines may each have an inlet which is connected to the low temperature section of the power generation circuit between the outlet of the low pressure compressor and the inlet of the high pressure side of the recuperator and an outlet which is connected to the high temperature section of the power generation circuit at a position upstream of the associated high pressure turbine, low pressure turbine, power turbine and inlet of the low pressure side of the recuperator, as the case may be.

The power generation circuit may make use of a direct closed Brayton cycle as the thermodynamic conversion cycle.

The reactor is typically of the pebble bed type having a core which includes a plurality of spherical fuel elements or pebbles.

The Brayton cycle typically has a high temperature section and a lopw temperature section corresponding to the high temperature section and low temperature section respectively, of the power generation circuit. Typically, the transitions between the high temperature section and low temperature section occur within the recuperator.

To facilitate control of the plant, a recirculation valve configuration and associated control system are designed to address the requirements of being able to operate under various load conditions and to accommodate abrupt loss of load with the minimum impact.

The Inventor believes that the invention will find application particularly when mass flow through the reactor core is reduced resulting in a decrease in fluidic power. This can occur when the recirculation

valve configuration is opened in order to compensate for a reduction in power demand. As a result, the power delivered by the power turbine will decrease due to the bigger fraction of available power being consumed by the compressors as well as the decreased efficiency of the power turbine owing to the lower mass flow therethrough. As a result, the gas temperature entering the high pressure turbine, low pressure turbine, power turbine and low pressure side of the recuperator tend to increase. This is due to the fact that the reactor outlet temperature remains the same, but less heat is removed by the high pressure turbine, low pressure turbine and power turbine. This increase in temperature can be compensated for making use of the coolant valves as described above.

In addition, during decay heat removal, flow of helium is achieved by a start-up blower system. However, the start-up blower system delivers relatively lower flow rate than the compressors and as a result, the possibility of the temperature of the gas entering the turbines or recuperator increasing exists. Once again, the coolant valves can be used in the manner described above to regulate the temperature of gas entering the various components.

The invention will now be described, by way of example, with reference to the accompanying diagrammatic drawing which shows a schematic representation of part of a nuclear power plant in accordance with the invention.

In the drawing, reference numeral 10 refers generally to part of a nuclear power plant in accordance with the invention.

The nuclear power plant 10 includes a closed loop power generation circuit, generally indicated by reference numeral 12. The power generation circuit 12 includes a nuclear reactor 14 and a power conversion unit, generally indicated by reference numeral 16.

The power conversion unit 16 includes a high pressure turbine 18, a low pressure turbine 20, a power turbine 22, a counterflow recuperator 24, a pre-cooler 26, a low pressure compressor 28, an intercooler 30 and a high pressure compressor 32.

The reactor 14 is a high temperature helium cooled pebble bed reactor making use of spherical fuel elements. The reactor 14 has an inlet 14.1 and an outlet 14.2.

The high pressure turbine 18 is drivingly connected to the high pressure compressor 32 and has an upstream side or inlet 18.1 and a downstream side or outlet 18.2, the inlet 18.1 being connected to the outlet 14.2 of the reactor 14.

The low pressure turbine 20 is drivingly connected to the low pressure compressor 28 and has an upstream side or inlet 20.1 and a downstream side or outlet 20.2. The inlet 20.1 is connected to the outlet 18.2 of the high pressure turbine 18.

The nuclear power plant 10 includes a generator, generally indicated by reference numeral 34 to which the power turbine 22 is drivingly connected. The power turbine 22 includes an upstream side or inlet 22.1 and a downstream side or outlet 22.2. The inlet 22.1 of

the power turbine 22 is connected to the outlet 20.2 of the low pressure turbine 20.

The recuperator 24 has a low pressure side 36 and a high pressure side 38. The low pressure side of the recuperator 36 has an inlet 36.1 and an outlet 36.2. The inlet 36.1 of the low pressure side is connected to the outlet 22.2 of the power turbine 22.

The pre-cooler 26 is a helium to water heat exchanger and includes a helium inlet 26.1 and a helium outlet 26.2. The inlet 26.1 of the pre-cooler 26 is connected to the outlet 36.2 of the low pressure side 36 of the recuperator 24.

The low pressure compressor 28 has an upstream side or inlet 28.1 and a downstream side or outlet 28.2. The inlet 28.1 of the low pressure compressor 28 is connected to the helium outlet 26.2 of the pre-cooler 26.

The intercooler 30 is a helium to water heat exchanger and includes a helium inlet 30.1 and a helium outlet 30.2. The helium inlet 30.1 is connected to the outlet 28.2 of the low pressure compressor 28.

The high pressure compressor 32 includes an upstream side or inlet 32.1 and a downstream side or outlet 32.2. The inlet 32.1 of the high pressure compressor 32 is connected to the helium outlet 30.2 of the intercooler 30. The outlet 32.2 of the high pressure compressor 32 is connected to an inlet 38.1 of high pressure side of the recuperator 24. An outlet 38.2 of the high pressure side of the recuperator 24 is connected to the inlet 14.1 of the reactor 14.

The nuclear power plant 10 includes a start-up blower system, generally indicated by reference numeral 40, connected between the outlet 36.2 of the low pressure side 36 of the recuperator 24 and the inlet 26.1 of the pre-cooler 26.

The start-up blower system 40 includes a normally open start-up system in line valve 42 which is connected in line between the outlet 36.2 of the low pressure side of the recuperator and the inlet 26.1 of the pre-cooler 26.

A low pressure compressor recirculation line 48 extends from a position between the outlet or downstream side 28.2 of the low pressure compressor 28 and the inlet 30.1 of the intercooler 30 to a position between the start-up blower system 40 and the inlet 26.1 of the pre-cooler 26. A normally closed low pressure recirculation valve arrangement 50 is mounted in the low pressure compressor recirculation line 48.

A high pressure compressor recirculation line 52 extends from a position between the outlet or downstream side of 32.2 of the high pressure compressor and the inlet 38.1 of the high pressure side 38 of the recuperator 24 to a position between the outlet or downstream side 28.2 of the low pressure compressor 28 and the inlet 30.1 of the intercooler 30. A normally closed high pressure recirculation valve arrangement 53 is mounted in the high pressure compressor recirculation line 52.

The power generation circuit 12 hence has a high temperature section, generally indicated by reference numeral 60 which is on the

reactor side of the recuperator 36 and a low temperature section, generally indicated by reference numeral 62 which is on the other side of the recuperator 36. The transitions between the high temperature section 60 and the low temperature section 62 typically occur at the recuperator 36.

The plant 10 includes four coolant feed lines 64, 66, 68, 70 in each of which a coolant valve 72, 74, 76, 78, respectively, is mounted.

In the embodiment shown, the coolant feed lines 64, 66, 68, 70 extend from a position between the outlet 32.2 of the high pressure compressor 32 and the inlet 38.1 of the low pressure side 38 of the recuperator 24 to positions upstream of the high pressure turbine 18, low pressure turbine 20, power turbine 22 and low pressure side 36 of the recuperator 24, respectively. The coolant feed lines could in fact lead from any position between the outlet 28.2 of the low pressure compressor and the inlet 38.1.

The plant 10 further includes temperature sensing means in the form of sensors 73, 75, 77, 79 for sensing the temperature of helium entering the high pressure turbine 18, low pressure turbine 20, power turbine 22 and low pressure side 36 of the recuperator 24, respectively. The temperature sensor 73 associated with the high pressure turbine is operatively connected to the coolant valve 72 to control the operation thereof. Similarly, the temperature sensors 75, 77, 79 associated with the low pressure turbine 20, power turbine 22 and low pressure side 36 of the recuperator 26 are operatively connected to the coolant valves 74, 76, 78, respectively.

The plant 10 which makes use of a Brayton cycle as the thermodynamic conversion cycle is designed for operation under various load conditions. The load conditions might vary from ordinary and frequent load variations, to a complete loss of load. The focus during these changes in load will be on keeping the plant synchronized with and connected to an electrical distribution grid, whilst keeping the Brayton cycle self-sustaining. This is desirable to ensure that the plant 10 can react promptly to demand variations. During normal operation, regular changes in required delivery are foreseen, and the plant is therefore designed to be able to accommodate the load changes with minimum impact on plant operation. The plant 10 is furthermore designed to be capable of accommodating an abrupt loss of load whilst again still remaining synchronized and connected to the grid, with the Brayton cycle continuing to be self-sustaining. This will typically result in the case of the power levels approaching zero with minimal or no delivery to the grid.

To this end the recirculation valve arrangements 50, 53 can be used to regulate the power output of the plant 10.

Accordingly, if there is a reduction in power demand, then one or both of the recirculation valve arrangement 50, 53 is opened. This results in reduced mass flow through the reactor core and therefore a decrease in fluidic power. The power delivered by the power turbine 22 will decrease due to the bigger fraction of available power being consumed by the turbo machines 28, 32 as well as the decreased efficiency of the power turbine 22 owing to the lower mass flow therethrough. In this case, the electrical power generated can be controlled and adjusted relatively quickly. However, when the power generated is reduced making use of the recirculation valves, the gas

temperature entering the high pressure turbine 18, low pressure turbine 20, power turbine 22 and low pressure side 36 of the recuperator 24 tend to increase. This is due to the fact that the reactor outlet temperature remains the same, but less heat is removed by the high pressure turbine 18, low pressure turbine 20 and power turbine 22.

However, in order to avoid possible damage to the turbines 18, 20, 22 or the recuperator 24, it is desirable that the maximum temperature of gas entering these components not exceed a predetermined maximum temperature (eg of the order of 600°C in the case of the recuperator 24). Accordingly, the temperature sensors73, 75, 77, 79 associated with each of these components sense the temperature of gas entering the associated components. Should the temperature of the gas exceed a predetermined maximum temperature, then the associated coolant valve 72, 74, 76, 78 is opened thereby to feed cooler helium from the low temperature section 62 to the high temperature section 60 which is mixed with the high temperature helium prior to its introduction into the turbine 18, 20, 22 or the recuperator 24, as the case may be.

In this way, the temperature of the gas entering the components can be maintained at a temperature below the predetermined maximum temperature thereby avoiding overheating and possible damage of the components on the high temperature section of the power generation circuit 12.

A secondary advantage associated with the opening of the coolant valves 72, 74, 76, 78 is that they will augment the compressor

recirculation valve power control process, as the coolant valves will in fact be acting as additional recirculation valves.

In addition to being used during normal operation of the plant, in the manner described above, the coolant valves 72, 74, 76, 78 can also be used during the process of decay heat removal. During decay heat removal the start-up blower system 40 is operational and is used to remove heat from the core. The start-up blower system 40 delivers relatively lower flow rates than the compressors 28, 33 and therefor the same situation as described above, ie the possibility of the temperature of the gas entering the turbines 18, 20, 22 or recuperator 24 exceeding the predetermined maximum temperature exists. Once again, the coolant valves 72, 74, 76, 78 can be used in the manner described above to regulate the temperature of gas entering the various components by mixing helium from the low temperature section of the power generation circuit with the high temperature gas stream.

It will be appreciated that, although the coolant valves 72, 74, 76, 78 have been described as single valves, they may in fact each comprise a valve set. The valve sets could include combinations of differently sized control valves or any other arrangement. Further, the control of the valves may be such that the valves can be used separately or in any required combination.

The Inventor believes that the invention will permit the plant to accommodate variations in load demand quickly and safely. It will also enable the removal of decay heat from the reactor, without causing damage to equipment in the high temperature section by exposure to temperatures above the maximum desired temperatures.

CLAIMS:

1. In a nuclear power plant which uses gas as the working fluid, there is provided a method of operating the nuclear power plant, which includes the steps of

monitoring the temperature of the gas entering at least one of the components of the power plant; and

if the temperature of the gas entering the at least one component of the power plant exceeds a predetermined maximum temperature, mixing cooler gas with the gas whose temperature has exceeded the predetermined maximum temperature, to reduce the temperature of the gas before it enters the at least one component.

2. A method as claimed in claim 1, which, when the nuclear power plant includes a high temperature gas cooled reactor and a power conversion unit which is connected together with the reactor in a closed loop and includes a high pressure turbine, a low pressure turbine, a power turbine, a counterflow recuperator having a high pressure side and a low pressure side, each side having an inlet and an outlet, a low pressure compressor to which the low pressure turbine is drivingly connected, and a high pressure compressor to which the high pressure turbine is drivingly connected, includes the steps of

monitoring the temperature of the gas entering at least one of the high pressure turbine, the low pressure turbine, the power turbine and the low pressure side of the recuperator; and

if the temperature of the gas entering the at least one of the high pressure turbine, low pressure turbine, power turbine, and low pressure side of the recuperator, exceeds a predetermined maximum temperature, mixing cooler gas with the gas the temperature of which has exceeded

the predetermined maximum temperature, to reduce the temperature of the gas before it enters the at least one of the high pressure turbine, low pressure turbine, power turbine and low pressure side of the recuperator.

3. A method as claimed in claim 2, which, when the reactor and the power conversion unit are connected together in a closed loop power generation circuit having a high temperature section and a low temperature section, includes feeding the cooler gas from the low temperature section of the power generation circuit to a position in the high temperature section of the circuit upstream of the at least one of the high pressure turbine, low pressure turbine, power turbine and low pressure side of the recuperator.

4. A method as claimed in claim 3, which includes regulating the flow of gas from the low temperature section of the circuit to the high temperature section of the circuit by means of at least one coolant valve.

5. A nuclear power plant which includes

a high temperature gas cooled reactor and a power conversion unit connected together with the reactor in a closed loop power generation circuit;

temperature sensing means for sensing the temperature of a gas entering at least one component of the power generation circuit;

at least one coolant feed line leading from a source of coolant gas to a position upstream of the at least one component; and

a coolant valve mounted in the coolant feed line and arranged to regulate the flow of coolant gas through the coolant feed line in response to signals received from the temperature sensing means thereby to

permit the temperature of the gas entering the at least one component to be regulated.

6. A nuclear power plant as claimed in claim 5, in which the power conversion unit includes a high pressure turbine, a low pressure turbine, a power turbine, a counterflow recuperator having a high pressure and a low pressure side, each side having an inlet and an outlet, a low pressure compressor to which the low pressure turbine is drivingly connected, a high pressure compressor to which the high pressure turbine is drivingly connected, a pre-cooler positioned in series upstream of the low pressure compressor and an intercooler positioned between the low pressure compressor and high pressure compressor, the power generation circuit having a high temperature section defined on the reactor side of the recuperator and a low temperature section defined on the other side of the recuperator, the plant including

temperature sensing means for sensing the temperature of gas entering at least one of the high pressure turbine, low pressure turbine, power turbine and low pressure side of the recuperator;

at least one coolant feedline extending from the low temperature section of the circuit to a position upstream of the at least one of the high pressure turbine, low pressure turbine, power turbine and low pressure side of the recuperator; and

a coolant valve mounted in the coolant feedline and arranged to regulate the flow of gas through the coolant feed line from the low temperature section of the circuit to the high temperature section of the circuit in response to a signal received from the temperature sensing means.

7. A nuclear power plant as claimed in claim 6, in which a temperature sensing means, a coolant feedline and a coolant valve are provided in respect of each of the high pressure turbine, the low pressure turbine, the power turbine and the inlet on the low pressure side of the recuperator to regulate the temperature of gas being fed thereto.

8. A nuclear power plant as claimed in claim 7, in which the coolant feedlines each have an inlet which is connected to the low temperature section of the power generation circuit between the outlet of the low pressure compressor and the inlet of the high pressure side of the recuperator and an outlet which is connected to the high temperature section of the power generator circuit at a position upstream of the associated high pressure turbine, low pressure turbine, power turbine and inlet of the low pressure side of the recuperator, as the case may be.

9. A method of operating a nuclear power plant as claimed in claim 1, substantially as described and illustrated herein.

10. A nuclear power plant as claimed in claim 5, substantially as described and illustrated herein.

11. A new method or plant substantially as described herein.

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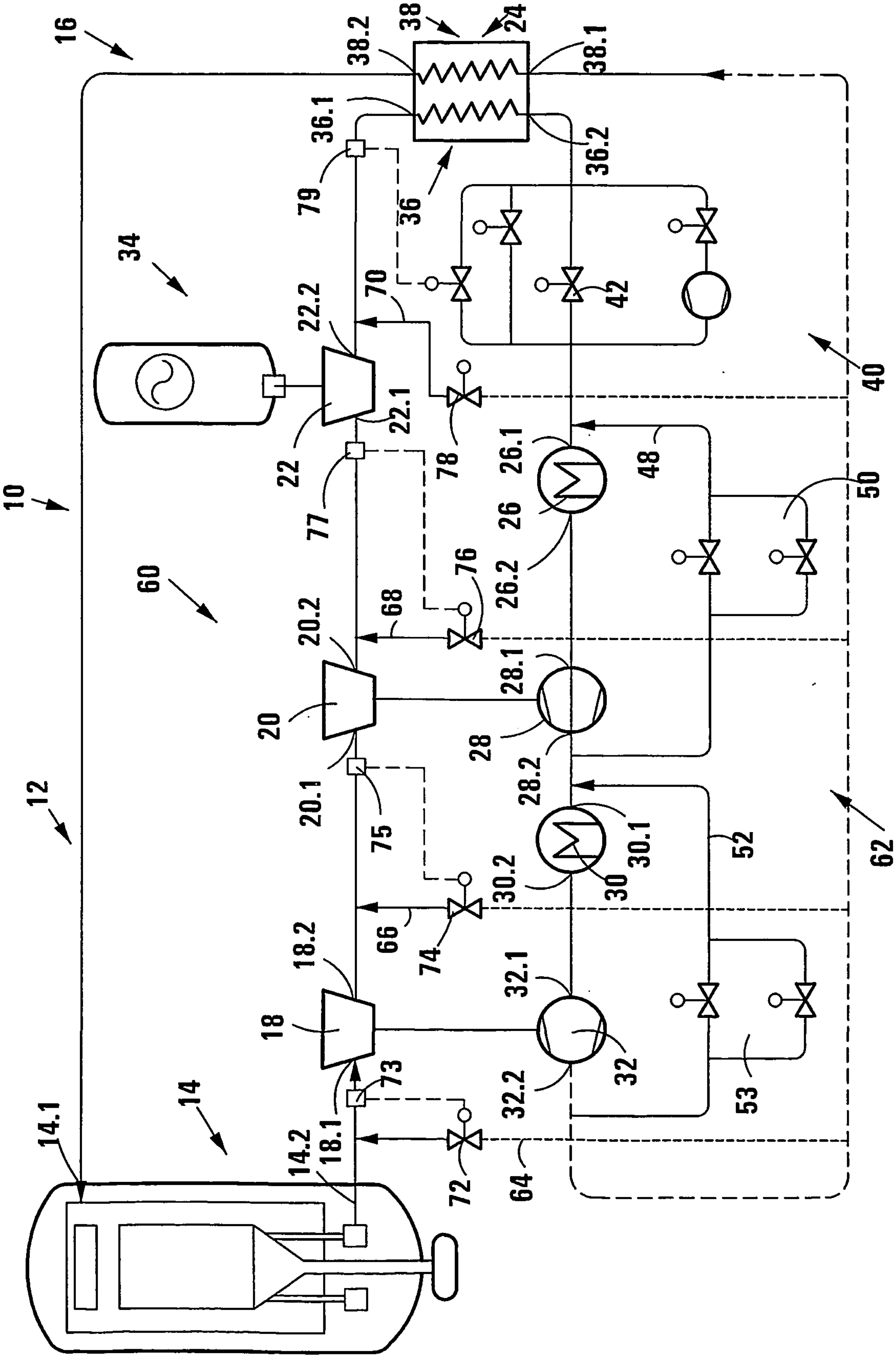
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INTERNATIONAL SEARCH REPORT

Interna Application No
PCT/IB 02/00979

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G21D3/08 F02C9/16 F02C1/05

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G21D F02C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 1 228 616 A (SULZER BROTHERS LIMITED) 15 April 1971 (1971-04-15) the whole document	1,5
A	US 4 000 617 A (FORTESCUE) 4 January 1977 (1977-01-04) the whole document	1,5
A	GB 1 275 755 A (ROLLS ROYCE LTD) 24 May 1972 (1972-05-24) the whole document	1,5
A	GB 2 307 277 A (BRANKO STANKOVIC) 21 May 1997 (1997-05-21) the whole document	1,5

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 July 2002	01/08/2002

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

Interna Application No
PCT/IB 02/00979

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 052 260 A (FORSTER ET AL.) 4 October 1977 (1977-10-04) the whole document ---	
A	US 4 193 266 A (FRUTSCHI) 18 March 1980 (1980-03-18) the whole document -----	

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB 02/00979

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 9-11
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box I.2

Claims Nos.: 9-11

Claims 9-11 do not state any additional comprehensible feature.

The applicant's attention is drawn to the fact that claims, or parts of claims, relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/IB 02/00979

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 1228616 A	15-04-1971	CH 476208 A	31-07-1969
		BE 718627 A	27-01-1969
		DE 1601650 A1	06-08-1970
		ES 356146 A1	01-01-1970
		FR 1576639 A	01-08-1969
		SE 341011 B	13-12-1971
		US 3503208 A	31-03-1970
US 4000617 A	04-01-1977	NONE	
GB 1275755 A	24-05-1972	CH 500376 A	15-12-1970
		DE 1946329 A1	20-08-1970
		FR 2022169 A5	31-07-1970
GB 2307277 A	21-05-1997	CA 2164648 A1	18-05-1997
US 4052260 A	04-10-1977	DE 2526147 A1	23-12-1976
		FR 2334176 A1	01-07-1977
		GB 1549730 A	08-08-1979
		JP 1335123 C	11-09-1986
		JP 51151498 A	25-12-1976
		JP 60057038 B	12-12-1985
US 4193266 A	18-03-1980	CH 622317 A5	31-03-1981
		DE 2737752 A1	15-02-1979
		FR 2398883 A1	23-02-1979
		JP 54025318 A	26-02-1979